CLAIMS

- 1. An on-signal calibration system for a transmitter that generates in-phase (I) and quadrature phase (Q) values and that converts, modulates and combines the I and Q values into a radio frequency (RF) output signal for transmission, said calibration system comprising:
 - a detector that senses the RF output signal and that provides a detection signal indicative thereof;
 - a sampler that samples said detection signal and that provides digital samples;
 - a selector that selects from among said digital samples that correspond to predetermined ranges of the I and Q values;
 - an imbalance estimator that determines at least one imbalance estimate based on selected digital samples; and
 - an IQ corrector that corrects said I and Q values using said at least one imbalance estimate.
- 2. The calibration system of claim 1, wherein said detector comprises an envelope detector.
- 3. The calibration system of claim 1, wherein said sampler comprises an analog to digital converter (ADC).

- The calibration system of claim 1, further comprising: 4.
 - said selector selecting digital samples that correspond with first and second selection boxes symmetrically located on either side of an I/Q origin on an I-axis of a plot of said I and Q values;
 - said selector selecting digital samples that correspond with third and fourth selection boxes symmetrically located on either side of said I/Q origin on a Q-axis;
 - wherein said imbalance estimator determines an I channel DC offset using selected digital samples of said first and second selection boxes and determined a Q channel DC offset using selected digital samples of said third and fourth selection boxes.
- 5. The calibration system of claim 1, further comprising:
 - said selector selecting digital samples that correspond with first and second selection boxes symmetrically located on either side of an I/Q origin on an I-axis of a plot of said I and Q values:
 - said selector selecting digital samples that correspond with third and fourth selection boxes symmetrically located on either side of said I/Q origin on a Q-axis; and

- wherein said imbalance estimator determines an amplitude imbalance estimate using selected digital samples.
- 6. The calibration system of claim 1, further comprising:
 - said selector selecting digital samples correspond
 with first and second selection boxes
 symmetrically located on either side of an I/Q
 origin on a 45 degree axis of a plot of said I
 and Q values;
 - said selector selecting digital samples that correspond with third and fourth selection boxes symmetrically located on either side of said I/Q origin on a 135 degree axis; and
 - wherein said imbalance estimator determines a phase imbalance estimate using selected digital samples.
 - 7. The calibration system of claim 1, further comprising:
 - a power circuit that determines digital power values using said digital samples and the I and Q values;
 - said selector selecting from among said digital power
 values; and
 - said imbalance estimator determining said at least one imbalance estimate based on a ratio of selected digital power values.

8. The calibration system of claim 1, further comprising:

- a magnitude circuit that determines digital magnitude values using said digital samples and the I and Q values;
- said selector selecting from among said digital
 magnitude values; and
- said imbalance estimator determining said at least one imbalance estimate based on a ratio of selected magnitude values.
- 9. A transmitter, comprising:
 - - an I/Q corrector that corrects said I and Q
 signals using at least one imbalance metric;
 - a hit detector that generates gate signals
 indicative of predetermined ranges of said I
 and Q signals;
 - a selector, coupled to said hit detector, that selects portions of a characteristic signal based on said gate signals; and

- an imbalance estimator, coupled to said selector and said imbalance estimator, that uses selected portions of said characteristic signal to determine said at least one imbalance metric:
- a radio frequency (RF) quadrature modulator that coverts said I and Q signals into an RF output signal; and
- an output signal detector that senses a characteristic of said RF output signal indicative of said at least one imbalance and that outputs said characteristic signal.
- 10. The transmitter of claim 9, wherein said output signal detector comprises an envelope detector and wherein said characteristic signal comprises an envelope signal.
- 11. The transmitter of claim 9, wherein said baseband processor further comprises:
 - a core that generates I and Q digital values;
 - a sampler that samples said characteristic signal and that provides digital samples;
 - said hit detector providing said gate signals indicative of a plurality of symmetric selection boxes at predetermined phases of said I and Q digital values; and

said selector selecting from among said digital
 samples based on said gate signals.

- 12. The transmitter of claim 11, wherein:
 - said imbalance estimator determines an I DC offset based on digital samples corresponding with selection boxes at 0 and 180 degrees; and
 - wherein said imbalance estimator determines a Q DC offset based on digital samples corresponding to selection boxes at 90 and 270 degrees.
- 13. The transmitter of claim 11, wherein said imbalance estimator determines an amplitude imbalance based on digital samples corresponding to selection boxes at 0, 90, 180 and 270 degrees.
- 14. The transmitter of claim 11, wherein said imbalance estimator determines a phase imbalance based on digital samples corresponding to selection boxes at 45, -135, 135 and 315 degrees.
- 15. The transmitter of claim 11, wherein said baseband processor further comprises:
 - said imbalance estimator providing at least one
 imbalance error value using said selected digital
 samples; and

- an integrator, coupled to said imbalance estimator and said I/Q corrector, that integrates each said at least one imbalance error value to provide said at least one imbalance metric.
- 16. The transmitter of claim 11, wherein said baseband processor further comprises:
 - a power circuit, coupled to said core and said sampler, that determines and provides digital power values based on said I and Q digital values and said digital samples;
 - said selector selecting from among said digital power values and sorting selected digital power values into first and second sets of digital power values; and
 - said imbalance estimator using said first and second sets of digital power values to determine said at least one imbalance metric.
- 17. The transmitter of claim 16, wherein said baseband processor further comprises a first average block that averages said first set of digital power values and a second average block that averages said second set of digital power values.
- 18. The transmitter of claim 16, wherein said baseband processor further comprises:

said selector providing said first set of digital power values as I power values corresponding to 0 and 180 degree selection boxes and said second set of digital power values as Q power values corresponding to 90 and 270 degree selection boxes; and

- said imbalance estimator calculating a ratio of said Q
 and I power values for providing an amplitude
 imbalance metric.
- 19. The transmitter of claim 16, further comprising:
 - said selector providing said first set of digital power values as first phase power values corresponding to 45 and -135 degree selection boxes and said second set of digital power values as second phase power values corresponding to 135 and 315 degree selection boxes; and
 - said imbalance estimator calculating a differential of said first and second phase power values for providing a phase imbalance metric.
- 20. The transmitter of claim 11, wherein said baseband processor further comprises:
 - a magnitude circuit, coupled to said core and said sampler, that determines and provides digital magnitude values based on said I and Q digital values and said digital samples; and

- said selector selecting from among said digital magnitude values and sorting selected digital magnitude values into first and second sets of digital magnitude values; and
- said imbalance estimator using said first and second sets of digital magnitude values to determine said at least one imbalance metric.
- 21. The transmitter of claim 11, wherein said baseband processor further comprises a digital delay block that receives said I and Q digital values and that provides delayed I and Q digital values.
- 22. The transmitter of claim 21, wherein said baseband processor further comprises a fractional delay device that delays said digital samples to align timing with said delayed I and Q digital values.
- 23. A method of on-signal calibration of a radio frequency (RF) quadrature modulator which modulates in-phase (I) and quadrature phase (Q) signals incorporating I and Q digital values into an RF output signal, comprising:
 - detecting the RF output signal and providing a
 detection signal;
 - sampling the detection signal and providing digital
 samples;
 - selecting from among the digital samples corresponding to predetermined ranges of the I and Q digital values:

estimating at least one imbalance metric using selected digital samples; and

- calibrating the I and Q signals using the at least one imbalance metric.
- 24. The method of claim 23, wherein said detecting the RF output signal and providing a detection signal comprises detecting an envelope of the RF output signal and providing an envelope signal.
- 25. The method of claim 23, wherein:
 - said selecting comprising selecting digital samples corresponding to first, second, third and fourth symmetrical selection boxes at 0, 90, 180 and 270 degree phase, respectively; and
 - wherein said estimating comprising estimating an I channel DC offset using the digital samples of the first and third symmetrical selection boxes, and estimating a Q channel DC offset using the digital samples of the second and fourth symmetrical selection boxes.
- 26. The method of claim 23, wherein:
 - said selecting comprising selecting digital samples corresponding to first, second, third and fourth symmetrical selection boxes at 0, 90, 180 and 270 degree phase, respectively; and

wherein said estimating comprising estimating an amplitude imbalance using the selected digital samples.

27. The method of claim 23, wherein:

said selecting comprising selecting digital samples corresponding to first, second, third and fourth symmetrical selection boxes at 45, 135, 225 and 315 degree phase, respectively; and

wherein said estimating comprising estimating a phase imbalance using the selected digital samples.

28. The method of claim 23, wherein:

said selecting comprising selecting digital samples corresponding to first, second, third, fourth, fifth, sixth, seventh and eighth symmetrical selection boxes at 0, 45, 90, 135, 180, 225, 270 and 315 degree phase, respectively; and

- wherein said estimating comprising determining an I channel DC offset error using selected digital samples of the first and fifth selection boxes, determining a Q channel DC offset error using selected digital samples of the third and seventh selection boxes, determining an amplitude imbalance error using selected digital samples of the first, third, fifth and seventh selection boxes, and determining a phase imbalance error using selected digital samples of the second, fourth, sixth and eighth selection boxes.
- 29. The method of claim 28, further comprising integrating the I channel DC offset error, the Q channel DC offset error, the amplitude imbalance error and the phase imbalance error over time using corresponding loop multipliers.
- 30. The method of claim 23, further comprising:
 - determining power values using the digital samples and the I and Q digital values.
 - said selecting comprising selecting power values corresponding to symmetrical selection boxes at 0, 90, 180 and 270 phase; and
 - said estimating comprising estimating an amplitude imbalance using the selected power values.
- 31. The method of claim 23, further comprising:

- determining power values using the digital samples and the I and Q digital values;
- said selecting comprising selecting power values corresponding to symmetrical selection boxes at 45, 135, 225 and 315 phase; and
- said estimating comprising estimating a phase imbalance using the selected power values.
- 32. The method of claim 23, further comprising:
 - determining magnitude values using the digital samples and the I and Q digital values.
 - said selecting comprising selecting magnitude values corresponding to symmetrical selection boxes at 0, 90, 180 and 270 phase; and
 - said estimating comprising estimating an amplitude imbalance using the selected magnitude values.